

## PREPOSITION SEMANTIC ANALYSIS VIA PERSIAN TEXT CORPUS

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### ABSTRACT

Prepositions are considered as frequent linguistic units, whose role in computational linguistics cannot be neglected. These units are often thought to have functional meaning. On the other hand, in some cases, the substitution of one particular preposition with another one would change the meaning of a sentence. This paper argues that prepositions are not meaningless units, which are only used for the purpose of sentence cohesion. The central goal of the research is to show that prepositions are meaning distinguishing elements. In order to achieve this goal, five Persian prepositions are examined in a Persian text corpus. Firstly, 1000 sentences consisting of these prepositions are extracted randomly from a text corpus. Next, the meaning of each preposition is assigned based on the linguistic context. Finally, each preposition is replaced by other prepositions in order to examine any change in the sentence meaning. The findings indicate that approximately 53% of prepositions, when replaced by other prepositions can cause a great change in the meaning of the whole sentence. Besides, it is argued that the resulting change in the meaning of sentences is systematic. That is, the semantic change after prepositions substitution is predictable.

**Key words:** Preposition, Text Corpus, Computational Linguistics

### 1. INTRODUCTION

"Preposition is a term used in the grammatical classification of words, referring to the set of items which typically precede noun phrases (often single nouns or pronouns), to form a single constituent of structure" (1).

Linguists and grammarians hold different views concerning the meaning of prepositions. Linguists can be classified into two general groups in respect to their views on the semantic of prepositions. The first group consider prepositions to be functional units whose role is connecting different elements in a sentence. In addition, prepositions are thought to be semantically insignificant units which are used to make a grammatical sentence not a meaningful one. According to Bannard and Baldwin (2), "Prepositions are often considered to have too little semantic content or be too polysemous to warrant a proper semantic description." Moreover, Marina (3) states that "Prepositions do not have semantical autonomy, that is why they cannot have syntactical functions."

Shaghghi (4) puts it in the way that prepositions are functional units which do not have any semantic content. As Natelkhanleri (5) points out, "prepositions are words which do not bear any independent meaning. They are used to introduce predicate complement".

On the other hand, the second group is linguists who believe that prepositions bear semantic information. They indicate that each preposition convey a variety of meanings based on the context in which it occurs. As a result, they establish the basic senses of each preposition.

Prepositions are considered as meaningful units in (6-8). Likewise, (9) introduces various senses for each preposition. For instance, he defines preposition *be* (with) with different senses like: MEANS, GOAL, and EXPLANATION. According to (10-11), prepositions convey different senses. In their paper, Mansuriheredast et al. (12) put an emphasis on semantic representation of Persian prepositions in conceptual graphs.

Hurford et al. (13) explain how to represent the proposition with logical formulae. They suggest that if prepositions contribute to the sense of the sentence, they should be used in the logical representation.

Saint-Dizier (14) suggests that prepositions can be viewed as a lexical category. This is due to the fact that they have type restrictions on their arguments, they assign thematic roles, and they have a semantic content.

Snider (15) is concerned with English sentences that differ in terms of prepositions "At" and "To". As observed by Snider, prepositions have significant role in conveying the meaning of sentences.

In his article, Jamrozik and Gentner (16) claim that the prepositions "in" and "on" retain aspects of their spatial meaning in abstract context.

In addition, it is a widely accepted belief among cognitive linguists that prepositions are meaningful. Tyler and Vyvyan (17) focus on the issue of semantic polysemy of English preposition "over" within a cognitive linguistic framework. Dolores portorequejo (18) notes that "Prepositions are highly polysemous words". Other cognitive studies can be found in (19-21).

These different points of views necessitate more research in this field; as a result, this research is concerned with the semantic analysis of Persian prepositions.

There is evidence to suggest that the substitution of one particular preposition with another one, in some cases, would change the meaning of a sentence. For instance, if the underlined preposition, in the following sentence, is replaced by other prepositions such as: toward, from, for, into, at, and through, the meaning would completely change.

(1) X went to the gate.

This paper focuses on the semantic analysis of Persian prepositions, using the notion of paradigmatic relation. In doing so, Persian sentences containing /{ζ (from), /δ{ρ (in), /τα: (to/ until), /βα: (with), /be/ (to) are extracted from a Persian text corpus. Each of these five prepositions is in paradigmatic relation with other potential prepositions. Consequently, each preposition is substituted with other prepositions to analyse any semantic change in the sentences. Furthermore, each preposition is assigned a semantic tag to examine whether the subsequent change in the sentence meaning is rule governed or not.

The central claim of this paper is that prepositions are meaning distinguishing units. The paper argues that preposition substitution would modify the meaning of 53% of the sentences. Besides, it is argued that the resulting change in the meaning of sentences is systematic. That is, the semantic change after prepositions substitution is predictable.

The paper is organized as follows: Section 2 describes the importance of prepositions in natural language processing. Section 3 introduces the methodology and procedures in this research. Results of the research are presented in section 4. Finally, section 5 includes conclusion and proposes different suggestions for further researches.

## 2. PREPOSITION AND NATURAL LANGUAGE PROCESSING

According to Snider (15), "Computational linguists have been attempting to decipher and formally codify the syntax and semantics of natural language, paying special attention to nouns, verbs, and adjectives, typically considered the bigger, meatier, semantically more satisfying units of language". The commonly held belief is that prepositions are semantically insignificant units. Consequently, little or no attention is paid to prepositions in computational linguistics. However, to overlook prepositions would undoubtedly cause difficulties in natural language processing (NLP). Reduction of precision or accuracy of systems is among these difficulties. In this section, the role of prepositions in NLP would be exemplified.

Word Sense Disambiguation (WSD) is one of the NLP tasks, which is concerned with determining the exact meaning of a word in a context. In most cases the main focus of WSD systems are on lexical morphemes like verb, adjective and nouns. But little or no attention is paid to preposition sense disambiguation in Persian. Perhaps this is because prepositions are thought to have no sense. Nevertheless, several works have been conducted in English for preposition sense disambiguation. Among these works are (10-18). The following sentences indicate that a preposition like /β{ρ (ON), might express various senses in different contexts:

(2) κολα:η β{ρ σ{ρ γοζα:Στ π{ ζΞα:νε β{ρYν ρ{φτ  
hat on head put. PST-3SG and from home out go. PST-3SG  
'She put on a hat and went out of the house.'

(3) β{ρ Σομα:στ κε δονβα:λε ?Y βερ{πιδ  
duty GL-COP.2SG to follow PRO go. PRS-IMP-2PL  
'It is your duty to follow him.'

(4) β{ρ μ{ν Ξ{Σμ γερεφτ  
at PRO anger get. PST-3SG  
'He angered at me.'

In the first sentence this preposition conveys the meaning of ON. While in the next case, it has another meaning; that is, OBLIGATION. Finally, the last one means AT. Thus, it is essential to specify the exact meaning of prepositions in the sentences.

Another important point is the significance of WSD systems in other NLP applications like machine translation. Table (1) indicates the sentences in which /τα: (to/ until), can have different equivalents in English with regards to the various meanings that it conveys in Persian and various functions (like "preposition" or "conjunction") that it has.

**Table 1.** Different equivalents of /τα: (to/ until) in English

Persian sentences	English translation
(1) μ{ν μια:φ{μ τα: το PRO come. PRS-1SG in order to/ to PRO ρ{α: βεβ{ν{μ OBL see. INF	'I come <u>in order to/ to</u> see you'
(2) ζ{ τ{βριζ τα: τεηρα:ν from Tabriz to Tehran	'From Tabriz <u>to</u> Tehran'
(3) τα: φ{ρδα: σοβη until tomorrow morning	' <u>Until</u> tomorrow morning'

Number (1) is an example of /τα: (to/ until), functioning as a conjunction, so the English equivalent is "In order to" or "To". However, this unit in the next sentence means PLACE. In the last example it conveys the meaning of TIME, thus "Until" is selected as its equivalent in the English translation. The above examples indicate that preposition WSD is required, in order to specify the exact meaning of a preposition before the process of translation begins.

It is worth noticing that there is a difference between the translation of prepositions and particles in phrasal verbs. Prepositions are linguistic units that have diverse equivalents in different languages. However, particles and verbs in phrasal

verbs should be translated as one unit. Consequently particles in contrast with prepositions cannot be translated separately. Machine translations, such as Google, do not consider this difference so the resulting translation is not an accurate one. In the following sentence "show off" is a phrasal verb which consists of "show" as a verb and "off" as a particle. These two elements should not be translated as two separate units; nonetheless, Google translates each part separately with no attention to the particle.

(5) He showed off his new car.

Google translation: ?Y νεΣα:ν δα:δ Ξοδροφε δΖ{διδε κηοδ ρα:

PRO show.PST-3SG carnew PRO OBL

'He showed his new car.'

Besides WSD and machine translation, prepositions are substantial units in other NLP applications like information retrieval (IR) and search engines. Information retrieval is the task of retrieving documents which are relevant to the users' needs. If lexical morphemes are the only linguistic units which are considered in search engines, the retrieved documents would not satisfy the users' needs in some cases. For instance two queries, "Immigration to Iran" and "Immigration from Iran", are equal in regard to lexical units. Nonetheless, what makes them different from semantic point of view is the choice of prepositions "To" and "From". It is certain that excluding prepositions in such cases would result in retrieving irrelevant documents and decreasing the precision of the IR systems.. As Baldwin et al.(31)states, "In information retrieval and information extraction, it would seem desirable to be able to predict that "book on NLP" and "book about NLP" mean largely the same thing, but "paranoid about drugs" and "paranoid on drugs" suggest very different things."

### 3. METHODOLOGY

This research is conducted in four major steps, which will be discussed in the next sections:

- Extracting sentences from a Persian text corpus
- Semantic tagging of prepositions in the extracted corpus
- Substituting prepositions with other prepositions
- Semantic analysis of prepositions

#### 3.1. Extracting Sentences from a Persian Text Corpus

The corpus which is used in this study is Persian Text Corpus. This corpus is a tagged one that is suitable for natural language processing research on the Persian (Farsi) language. The corpus is gathered from daily news and common texts, and all documents are categorized into different subjects such as political, cultural and so on. Totally, there are 4300 different subjects.

The sentences, extracted automatically from this corpus, consist of five most frequent Persian prepositions /{ζ/(from), /δ{ρ/(in), /τα:(to/ until), /βα:(with), /βε/(to). The sentences are extracted randomly in order for the extracted corpus to be a representative of natural language; furthermore, these sentences are selected from different genres of Bijankhan corpus (32). Around 200 sentences are examined for the analysis of each preposition. Therefore, the final extracted corpus consists of 1000 sentences.

Since the crucial focus of this paper is on semantic analysis of simple prepositions, homonymous words are not taken into account. Homonyms are words with the same spelling and pronunciation. In Persian, prepositions, affixes, verb particles, and prepositional component of compound prepositions are homonyms. Due to the fact that such units are not preposition, they are excluded from further semantic analysis in this research. In the following section, distinctions among these four items would be exemplified.

Prepositions and particles

"Phrasal verb is a verb idiom which consists of two words, (a) a main verb, such as take, find, and (b) a prepositional adverb (often called a particle), such as off, out, away. Thus take off, carry on, and find out are examples of phrasal verbs" (33). Particles are required in some sentences, so that they would complete the meaning of a verb; nonetheless, they do not convey any meaning by themselves. Phrasal verbs are specified in the sentences below. In these examples /βε/ (to) is a particle but not a preposition.

(6) δ{ρ η{μιν ηα:λ σεδαφε ζ{νγ βε γυΣ ρεσιδ

at this moment bell was heard.PST-PAS

'At this moment, the bell was heard.'

(7) εβα:ρα:τ π{ εστελα:ηα:τι κε δ{ρ ιν θανYν βε κα:ρ ρ{φτε {στ

phrases and vocabularies which in this law are used. PST-PAS

'Phrases and vocabularies which are used in this law.'

Simple prepositions and compound prepositions

According to crystal compound is a linguistic unit composed of elements that function independently in other circumstances. Compound prepositions have an internal structure that can be broken into smaller independent units. For instance /βεδZoζ/(except) is a compound preposition which is composed of two simple prepositions /βε/ and /δZoζ/. Other compound prepositions such as: /βεδονβα:λε/ (looking for), and /βε?ελλ{τε/(due to) have the same morphological structure. These compound prepositions are underlined in the sentences (8) and (9).

(8) μ{ρδομ νεμιδα:ν{νδ

Ξοδ βεδονβα:λε

τΣε people do not know.NEG-PRS-3PLPRO

looking for. PRS-GER-3PL what

η{στ{νδ

are.PRS-COP-3PL

'People do not know what they are looking for.'

(9) βε?ελλ{τε βα:ρεΣε Σ{διδ βοζοργαη μ{σδYδ Σοδε {στ

due to rain heavy/highway blocked is.PRS-COP-3SG

"Due to heavy rain, the highway is blocked."

Prepositions and affixes

The underlined elements in the following sentences seem to be prepositions; nonetheless all of them are used as prefix.

(10) α:δ{μ κε σε:ννεΣ βα:λα: μιρε φα:δ μιγίρε κε βα:επιφα:τ βα:Σε  
peoplewhen grow up.PRS-3PLlearn. PRS-3PL tocautiousbe.COP  
'When people grow up, they learn to be cautious.'

(11) ?ν δΥστι βα:π{φα: βΥδ  
PRO friend loyal was.PST-COP-3SG  
'He was a loyal friend.'

### 3.2. Semantic Tagging of Prepositions in the Extracted Corpus

In this phase, each preposition is assigned a semantic tag based on its linguistic context. The tags, which are selected from "Sokhan Dictionary" (34), indicate the sense of each preposition. Compared with other Persian dictionaries, this dictionary covers the widest range of preposition senses. For instance, in this dictionary, a variety of meanings such as: PLACE, ABOUT, TIME, CAUSE, AIM, and AS SOON AS are defined for /δ{p/(in).

In the following table semantic tags are assigned to /{ζ/(from) based on different contexts.

**Table 2.** Semantic tags assigned to /{ζ/(from)

Sentence	Semantic tag
(1) θαΣοθηα: ρα: {ζ α:Σπ{ζΞα:νε α:π{ρδε spoons OBL from kitchenbrought.PP {στ has.PRS-3PL 'He has brought the spoons from kitchen.'	PLACE
(2) {ζ σοβη τα: ηα:λα: μοντ{ζερ{τ η{στ{μ from morning till now waiting am.PRS-COP-1SG 'I am waiting for you from morning till now.'	TIME
(3) ιν βα:ρ {ζ σεδα:φε ?Υ βιδα:ρ Σοδ{μ this time to sound PRO woke up.PRS-1SG 'This time I woke up to his sound.'	CAUSE

### 3.3. Substituting Prepositions with Other Prepositions

Lyonse explains different relations between linguistic elements and he puts it in this way:

By virtue of its potentiality of occurrence in a certain context a linguistic unit enters into relations of two different kinds. It enters into paradigmatic relations with all the units which can also occur in the same context (whether they contrast or are in free variation with the unit in question); and it enters into syntagmatic relations. (35)

Therefore, in this section, prepositions are replaced by other prepositions in order to examine meaning alternation in the sentences. The analysed data indicated that in some cases this substitution would modify sentence meaning; nevertheless, in some sentences it would result in the sentence ungrammaticality. In table (3), prepositions that can modify the sentences meaning together with the changed meaning are stated. In the last three examples there is no preposition whose substitution causes the semantic change.

Sentence	Preposition to change the sentence meaning	Changed meaning in English
1- σ{ρι? βα: Σοη{ρανεΣαν δυρ Σ{π{νδ fastlywith their husbands get away.PRS-IMP-3PL 'They should get away <u>with</u> their husbands fastly.'	/ζ/(from)	'They should get away <u>from</u> their husbands'
2- (2)αα σαλε 1327 πεδ{ρ{μ εφαζε till1327 my father let.PST-3SG		
3- ν{δ{δ ψεκ ραδιωο δ{ρ did not. PST- NEG-AUX a radio at	/ζ/(from)	'My father did not let us have a radio at
5- μ{νζελε μα βαΣ{δ home PRO have	/δ{p/(in)	at home <u>from/in</u> 1327'
6- home PRO have home <u>till</u> 1327.'		

(3) *πρωδανεσφυναν ρα*  
PROstudents OBL  
*ιζ αμυζεσηαντε λαζεμ βιηρεμιν σαετε*  
with training required provided.PST-3SG  
'He provided the students with the required training.'

In some sentences, it is difficult to determine any semantic alternation in the sentences. Consequently, in such cases linguistic intuition of the Persian speakers are used. In doing so, questionnaires consisting of 40 sentences are distributed among Persian subjects who specify which preposition can change the meaning of each sentence. 93 participants are selected among both male and female Persian speakers. Moreover, age of the subjects with different educational backgrounds ranges from 16 to 64.

### 3.4. Semantic Analysis of Prepositions

The principal question which is concerned in this section is that: "whether the notion of preposition substitution and meaning modification is rule governed or not?" In order to accomplish this goal, several contexts, in which preposition substitution is either meaning distinguishing or ungrammatical, are specified.

The findings of this section are as follows:

a. In 99% of the contexts, where */τα:/(to/ until)*, means DISTINCTION, substitution of this preposition would result in the sentence ungrammaticality. For instance, preposition substitution in the following sentence is not allowed grammatically:

(12) *ιζ μιςα:ελε δινι γερεφτε τα: σιφα:σι*  
from issues religious to political  
'From religious issues to political issues'

b. If */βα:/(with)* conveys the meaning of POSSESSION, its replacement in 87% of the sentences is meaning distinguishing. In most examples this preposition can be replaced by ☐☐☐☐☐☐☐☐ to alternate the meaning of the whole sentence.

(13) *ιν ρεσα:λε βα: τ{ρομοφε φα:ρσιφε α:ν δ{ρ σα:λε* 1362  
this dissertation with translation Persian PRO in 1362  
*βε τσαπ ρεσιδ*  
was published.PST-PAS-3SG  
'This dissertation was published with its Persian translation in 1362.'

(14) *ιν ρεσα:λε βεδYνε τ{ρομοφε φα:ρσιφε α:ν δ{ρ σα:λε* 1362  
this dissertation without translation Persian PRO in 1362  
*βε τσα:π ρεσιδ*  
was published.PST-PAS-3SG  
'This dissertation was published without its Persian translation in 1362.'

c. In 90% of the sentences, in which */βα:/(with)* means TOGETHER or WITH, the preposition substitution would modify the interpretation.

d. If */βα:/(with)* has the internal meaning of BY and its complement is [+ abstract], its replacement with other units changes the meaning.

e. Conveying the sense of GOAL or MOTIVATION, */δ{ρ/(in)* can be replaced with other units in 92% of the cases to change the sentence meaning. With regards to this sense, */δ{ρ/(in)* complement is always a gerund.

f. There is a pattern for the substitution of */ιζ/(from)* and */τα:/(to/ until)* in all of the Persian sentences. The pattern, exemplified below, may convey TIME DISTANCE or PLACE DISTANCE between the first NP and the latter one.

NP + */ιζ/* + NP + */τα:/(*  
(15) *μοδδ{τε τ{φα:ηομνα:με ιζ τα:ριεε 2006 τα: 2013 μιβα:Σ{δ*  
Duration agreement from 2006 to 2013 is.PRS-COP-3SG  
'The agreement duration is from 2006 to 2013.'

The above example shows this pattern. In such patterns, neither of the prepositions can be replaced by other prepositions. This is because of the fact that any replacement would undoubtedly make the sentence ungrammatical. */ιζ/(from)* might be implied in the above pattern; that is, sense of DISTANCE or TRANSFORMATION is conveyed without */ιζ/(from)* being explicitly stated. For instance:

(16) *φασελεφε λ{νδ{ν τα: τοροντο ρα: η{ρφ μιζ{δμ*  
London to Toronto OBL talked.PST.1PL  
'We talked from London to Toronto.'

g. The previous pattern for the replacement of */ιζ/(from)* and */τα:/(to/ until)* can be restated for */ιζ/(from)* and */βε/(to)*. Compared with the previous pattern, the new pattern expresses PLACE DISTANCE and TIME DISTANCE. For example, in the following sentence both prepositions convey sense of PLACE but neither of them is allowed to be substituted with other elements.

(17) *πειιζ τορκφε βε δοβελ ταβ{ιδ γ{ρδιδ*  
PRO from Turkey to Dubai was expatriated. PST-PAS-3SG  
'He was expatriated from Turkey to Dubai.'

#### 4. RESULTS AND DISCUSSION

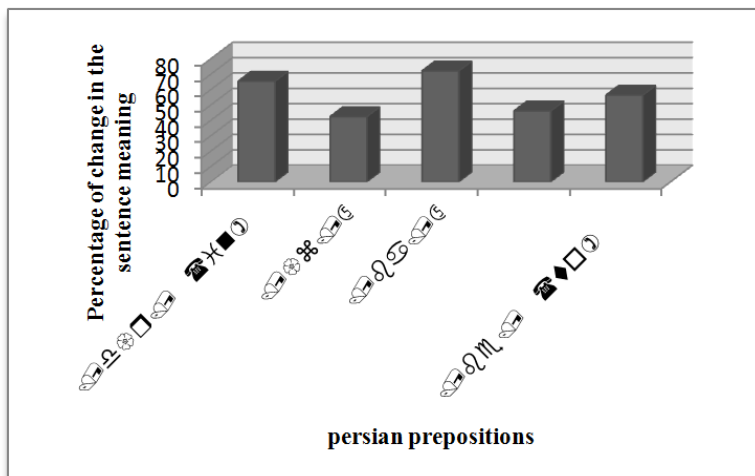
The main aim of this paper is the semantic analysis of Persian prepositions. In order to accomplish this goal, the research is conducted both as a library research and a field research. In the library research, sentences consisting of prepositions are extracted from the Persian text corpus. In the next step, semantic tags are assigned to simple prepositions. Finally, in order to examine what semantic role prepositions might play in the sentences, each preposition is substituted by other units.

In several cases, it is difficult to decide whether there is modification in the sentence meaning or not. Therefore, in the field research, such cases are prepared in the form of questionnaires which are distributed among Persian speakers.

Trying to sum up the most relevant results reached up to this point, we might want to state that:

a. Approximately 53% of the Persian prepositions can change the meaning of sentences. Thus, they are not dummy units without intrinsic semantic content.

b. As figure (1) shows  $/\beta\alpha:/(with)$  has the most meaning alternation compared with  $/\zeta/(from)$ ,  $/\delta\{p/(in)$ ,  $/\tau\alpha:/(to/ until)$ ,  $/\beta\alpha:/(with)$ ,  $/\beta\epsilon/(to)$  if it is replaced by other prepositions.



**Fig. 1.** Percentage of change in the sentence meaning after prepositions substitution

c. The context, in which preposition occur, is systematically selected; that is, a particular preposition cannot be substituted with every preposition; otherwise, the sentence would be ungrammatical. Furthermore, there are specific regularities for substitution of prepositions and the subsequent change in the sentence meaning.

d. This study argues against the idea that prepositions are extra units which can be neglected. There is evidence to suggest that disregarding such units in natural language processing would have negative effect on function of the systems.

e. Prepositions have various senses; however, each preposition does not convey different senses to the same degree. To clarify the point,  $/\zeta/(from)$  has numerous meanings such as: PLACE, TIME, MATERIAL, CAUSE, PART OF, DISTINCTION, CONSISTING OF. Nonetheless, this preposition conveys the meaning of PLACE in 31% and TIME in 15% of the corpus. In table(4) the most frequent senses conveyed by five Persian prepositions are stated:

**Table 4.** Senses of prepositions

Preposition meanings	Frequency of occurrence				
	$/\zeta/(from)$	$/\beta\epsilon/(to)$	$/\delta\{p/(in)$	$/\beta\alpha:/(with)$	$/\tau\alpha:/(to/ until)$
(1) PLACE	31%	44.33%	5.02%	-	17.67%
(2) TIME	15%	-	24.12%	-	64.14%
(3) REASON	3.5%	-	-	-	-
(4) WITH	3.5%	-	-	13.06%	-
(5) PART OF	9.5%	-	-	-	-
(6) CONNECTION AND ADDRESSEE	-	19.7%	-	10.55%	-
(7) AS	-	2.46%	-	-	-

(8) REASON	-	1.97%	-	-	-
(9) SIZE, AMOUNT, AND COST	-	2.46%	-	-	9.59%
(10) GOAL	-	-	5.52%	-	-
(11) QUALITY	-	-	4.52%	-	-
(12) ACTION	-	-	2.51%	-	-
(13) POSSESSION	-	-	-	15.57%	-
(14) TOGETHER	-	-	-	9.54%	-
(15) RESULT	-	-	-	18.09%	-
(16) DISTINCTION	-	-	-	-	7.57%
(17) Other meanings	37.5%	29.08%	58.31%	33.19%	1.03%

## 5. CONCLUSION

We started out this paper by posing the question of whether prepositions have internal content or they are semantically empty units. The rationale for this hypothesis came from the fact that the use of a preposition instead of another one modifies interpretation of sentences. This paper argues that prepositions are meaning distinguishing elements. It rejects the view shared by several linguists who consider prepositions as meaningless units. Moreover, it is found that meaning modification following from preposition substitution is predictable.

Probing the contexts in which each preposition bears specific meaning provides rich territory for future research. This is beneficial in WSD systems and other NLP applications requiring semantic analysis.

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